(Check) Enhancing Game Experience with Facial Expression Recognition as Dynamic Balancing

by Rini Wongso

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Enhancing Game Experience with Facial Expression Recognition as Dynamic Balancing

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Abstract

Player's Experience in the game has been known to be one of the essential keys for the success of the game. There are several methods exist to enhance the player's experiences in the games. One of the unexplored methods is a dynamic balancing system using Facial Expression Recognition. The player's facial expression is captured in real-time while the player is playing the game, and the dynamic balancing system will automatically adjust the game difficulty based on the player's facial expressions. This research aims to empirically explore the implementation of Facial Expression Recognition for a dynamic balancing system to enhance the player's experiences in the game. Two action games (2D and 3D) were developed and evaluated with 60 respondents in two groups. Both groups played the game twice, one with facial expression recognition system as dynamic balancing activated and one without. The results demonstrate that they are statistically significant differences (i.e. improvement) between the baseline and enhanced games with $p < 0.01$.

Keywords: Dynamic Balancing, Player's Experiences, Game Technology, Facial Expression Recognition

1. Introduction

Games have been known as the best entertainment tool in the world. The interesting fact about the game is that people (i.e. players) will voluntarily do unnecessary challenges in the game. They don't mind involved in a negative emotion situation (e.g. frustration, fear, sadness) when they face unnecessary challenges in the game. Both negative and positive emotions in the games establish experience in the game. Moreover, the player's emotions play an important part to affect the player's experiences in the game [1,2,3,4]. The emotional experiences are generally established when

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the player is interacting with the game objects (e.g game world, mechanics, etc.) through game input (e.g. keyboard, mouse, joystick, etc.). Hence, enhancing the player's experience during the game could be done in manipulating the game objects and/or inputs[5,6,7]. One of the renowned techniques to increase the player's satisfaction and experiences when playing a game is to manipulate the game balancing. Game balancing plays part to determine if the game is either too hard, too easy, balanced to the player. Too hard game would bring frustration to the player, while too easy game would bring boredom to the player[8]. The emotions (e.g. frustration, boredom, etc.) are generally voluntarily expressed through the player's facial expressions during the game. Providing this nature and the capability of automatic Facial Expression Recognition (FER) system, the balancing system could dynamically adjust the game difficulties based on the player's reaction to the current game difficulties.

Using player's FER to dynamically balance the game difficulties have been proposed in several works of literature[8,9]. However, only a few empirical experiments have been done to prove the concepts. Moniaga et al[8] propose a dynamic balancing system using FER in a Hack and Slash Game. While the dynamic balancing system resulted in the increase of the player's experiences during the game, we are not entirely sure that the dynamic balancing system would provide the same results in the other game genres. Different game genres would create different experiences for the players. Hence, this paper proposes a dynamic game balancing system with FER in the most popular game genre: Action. This research attempts to apply dynamic game balancing system to two action games made using Unity, one is a 2D action game and the other is a 3D action game. This hopefully provides more empirical insights into the research in this area. In general, five out of seven player's experiences variables categories have statistically significant differences (i.e. improvement) between the baseline and enhanced games ($p < 0.01$). Moreover, there is also no statistically significant differences in Negative Effect in the game category, in both groups.

2. Related Work

2.1. Dynamic Game Balancing

The effort to enhance player's experience when playing a game have been evolved from enhancing the feel and look (i.e. the aesthetic part of the game) to increase the intelligence of the agents (e.g. Non-Player Character, and the Enemies). Moreover, some researchers proposed a method to seamlessly blend the game reality into the player's reality by using Augmented/Virtual/Mixed Reality and/or sensors (GPS, Camera, Accelerometer, Gyroscope, Microphone, etc.). All those methods empirically enhanced the player's immersiveness as well as their engagements with other players or objects within the game. This finding also consistent with the other claim that one of the essential elements to build experience in the game and present it to the player is through engagements and immersiveness[6,7,8,2,5,4]. Enhancing the player's experience using the game's aesthetic is relatively easy to do, however, this method usually requires expensive graphics resources. The feel and look of the game is generally determined by the game's graphics[10,11,12] (e.g. animation, and appearance) and sounds[13,12] (e.g. sounds effect, voice, and background music). Meanwhile, enhancing player's experience during the game using virtual/mixed/augmented reality[14,15] and sensors[16,5] empirically provide the best game experience to the players. With those methods, the players will be able to interact with their physical (i.e. real) as well as the game virtual world. However, playing the game with virtual/mixed/augmented reality and sensors are still have several drawbacks: technology limitation, inflexible, and quite expensive to be implemented.

The most common methods to enhance the player's experience in the game is to enhance the intelligence of the agents (e.g. Non-Player Character, and the Enemies). Several techniques proposed to play around with the game agents' intelligence. Scripting Artificial Intelligence (AI) behaviours for the game character or Non-Player Character (NPC) is the most classic yet powerful technique to provide intelligence to the game agents. Some AI methods such as path findings have been mostly solved and remained used until today. However, some methods such as dynamic balancing is still a subject undergoing intense study as there is no general rules or methods to build a dynamic balancing system in a game. In general, a dynamic balancing system adjusts some pre-defined variables in the game to dynamically adjust the difficulty of the game. The pre-defined variables are generally adjusted in real-time based on the player's performance during the game. This method allows the players to feel the difficulty of the game is just right no matter the type/profile of the players (e.g. an expert in the game or a casual gamer). This leading to the increase of the player's experience in the game[17,8,18].

Table 1. Baseline of The Characters HP and AP in Both 2D and 3D Games

Character	Health Point	Attack Point
Player	800	10
Enemy	$180 + (20 * level)$	$2 + (3 * level)$
Boss	$1000 + (500 * level)$	$5 + (3 * level)$

2.2. Affective Game Design

The term of Affective Game was probably coined first by Eva Hudlicka [19] derived from Affective Computing [20] implemented in the game. The term of Affective Computing itself was coined first by Rosalind Picard [20] to categorise a study of recognising, processing, interpreting, and simulating human affects (i.e. the experiences of emotions and feelings). Hence, Affective Game can be used to express the implementation of recognising, processing, interpreting, and simulating the experiences of emotions and feelings in games. Implementing affects element in the game is empirically enhancing the player's experiences while playing in the game [19,3,1,2,21]. Several methods proposed to design an affective game, one of them is implementing the ability to recognising, processing, interpreting, and simulating the experiences of emotions and feelings to the agents (i.e NPCs, and Enemies) [22,2,21]. Sensors such as camera, or microphone can be used to capture player's affects (e.g. facial expressions, voice prosody) and then processed to be interpreted by the agents. Based on the agent's internal feelings, emotions and the interpreted emotions, the computational models of emotions in the agents will be simulating the emotions for the agents. Lastly, the agents should display the simulated emotions through their actions (e.g. words, voice prosody, and facial expressions) [22,2,21]. The method to capture player's affects can be implemented to dynamically adjust the game difficulty. For example: if the player shows a stress or anxiety face, the variables related to game difficulty can be lowered until the player shows a relaxed face. This can be achieved using Facial Expression Recognition (FER) installed to the game. The FER system automatically interprets the player's facial cues during the game. Only a few empirical experiments have been done to prove the concepts of FER for dynamic balancing in the game.

3. Methods

The research methods were divided into three main phases: the analysis phase, the game design and development phase, and lastly the evaluation phase. To provide the most general results, we aim the most general and most playable game genre. A simple questionnaire was distributed to our university and several online game forum. A total of 202 valid respondents with most of them (93.1%) are between 17-25 years old and 74.3% are Male. All the respondents are spending more than 3 hours-per-day to play games with 94.1% chose Action game genre for their favourite games. As the results suggested, in this research, two action desktop (i.e. Windows) games were developed to be implemented FER for a dynamic balancing system. The games were developed with an existing game engine, Unity with Scrum method as the Systems Development Life Cycle (SDLC) method. The FER system was developed with Affdex SDK from Affectiva [23]. With Affectiva, the FER system can detect seven emotions and twenty facial expressions from the camera enabling a real-time player's facial expression recognition during the game. The detected emotions and facial expressions then are interpreted by the FER system and passed to the game mechanics. In general, both games have a goal, some enemies, and a boss on every level. The variables chosen for dynamic balancing for both games are enemies speed & acceleration, player's health regen, enemies spawn time and player's damage-per-hit. The only difference is that, in the 3D game, the player is able to freely explore the open world, while in the 2D game, the player has to follow the path provided in the game. Fig. 1 illustrates the general flow of the game for both 2D and 3D games.

Subsection 3.1 illustrates the game and dynamic balancing system design for the 2D game, while Subsection 3.2 demonstrates the game and dynamic balancing system design for the 3D game. In general, there are two categories of expressions/emotions detected from the player's facial expressions. One (let's call it $\mathcal{E}_0$) will dynamically lower the difficulties through variables set, the other (let's call it $\mathcal{E}_1$) will dynamically raise the difficulties. The set value of $\mathcal{E}_0 \in \{e_0, e_1\}$ defined by the maximum value of expressions/emotions between Anger (e_0), and Frustration (e_1) captured from the system multiplied by -1. Moreover, the set value of $\mathcal{E}_1 \in \{e_2, e_3\}$ defined by the maximum value of expressions/emotions between Smile (e_2), and Relaxed (e_3) captured from the player's facial cues. Table 1 demon-

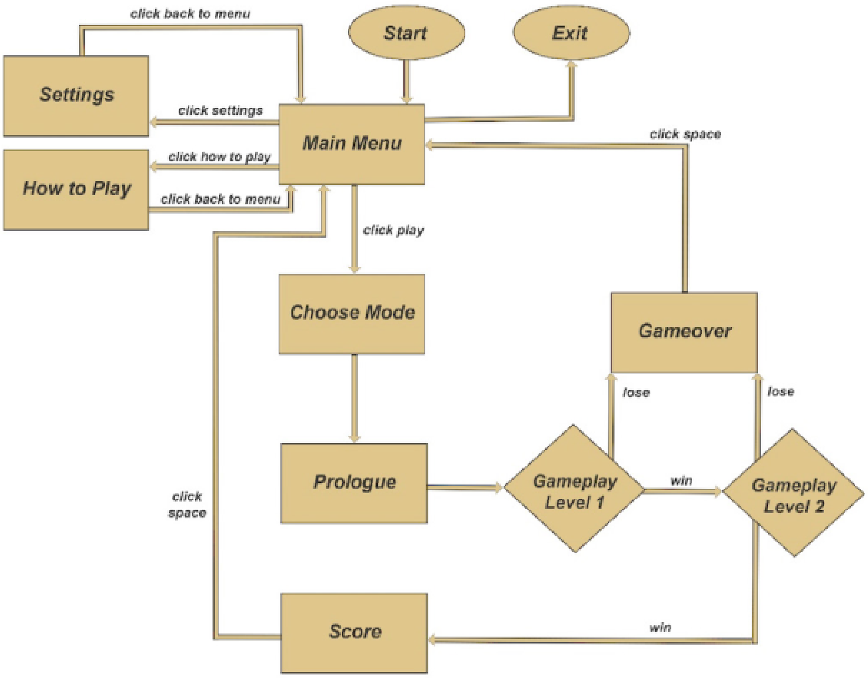


Fig. 1. Game Flowchart (2D and 3D)

Table 2. Dynamic Balancing Design for Both 2D and 3D games

Dynamic Balancing Variables	**Baseline**	**Dynamic Balancing**
Enemy's Speed & Acceleration	2 second	$MAX(baseline, baseline + MVAL(\mathcal{E}_0, \mathcal{E}_1))$
Player's Health regen	0 HP	$MAX(baseline, baseline - 5 * MVAL(\mathcal{E}_0, \mathcal{E}_1))$
Enemy's Spawn Time	6 seconds	$MAX(baseline, baseline + 2 * MVAL(\mathcal{E}_0, \mathcal{E}_1))$
Players Attack Point	10 AP	$MAX(baseline, baseline - 5 * MVAL(\mathcal{E}_0, \mathcal{E}_1))$

strates the baseline values for the Health Point (HP) and Attack Point (AP) of the players, enemy, and boss in both 2D and 3D Games. The values are used in both games, with and without dynamic balancing system. Table 2 shows the dynamic balancing design. There are four variables chosen to be the dynamic game balancing variables: Enemy's speed & acceleration, Player's health regen, Enemy's spawn time, and Player's Attack Point. All the value in the game with no FER installed as the dynamic balancing system will be the baseline. While the value of dynamic game balancing variables in the game with FER installed as the dynamic balancing system is dynamically adjusted based on the facial expressions/emotions captured with the minimum value is the baseline's value. A function $MVAL(\mathcal{E}_0, \mathcal{E}_1)$ return a value of $MAX(|\mathcal{E}_0|, |\mathcal{E}_1|)$. The value of $\mathcal{E}_0$ should be negative and the value of $\mathcal{E}_1$ should be positive. Hence, if the maximum value returned belongs to $\mathcal{E}_0$, the value returned will still remain a negative value.

Finally, both games were deployed and evaluated in two groups, the first group of respondents played the 2D game. The second group of respondents played the 3D game. Both groups played with two versions of the game: with and without dynamic balancing system. To avoid respondents' bias, the respondents were not told about the dynamic balancing system and the order between with and without dynamic balancing system were randomised. Meaning some respondents played with the dynamic balancing system first and then played the with-out dynamic balancing system. While the others played a game without a dynamic balancing system first. A questionnaire designed by The Game Experience Questionnaire (GEQ)[24] was filled by the respondents every time they finish the game.

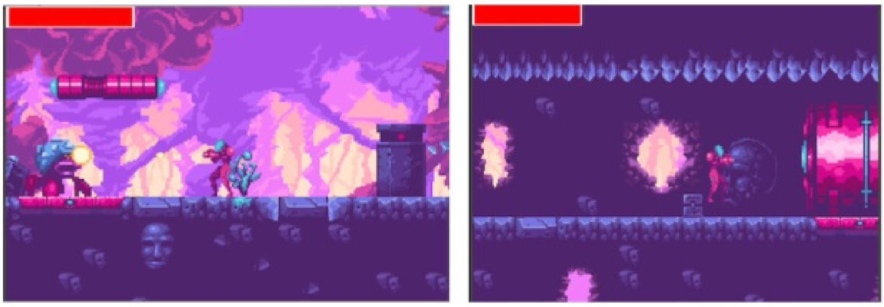


Fig. 2. 2D Game Play

Fig. 3. 3D Game Play

3.1. Alien Fighter: The 2D Game

Alien Fighter is a 2D game designed with an outer space setting with Alien theme. The player controlled a person with a gun that fights a bunch of Alien in an unidentified place. The goal of the game is simple: pass all levels by defeating all the enemies and the boss. Fig. 2 shows the Alien Fighter gameplay. The theme set to the game in outer space and the colour theme used in the game is quite dark to match the feeling of mystic outer space. The camera is set to be a third person view, where the player should follow the path provided in the game while defeating enemies. At the end of the path, the player will have to fight the level boss. The level of the game is set to two levels, in order to not make it too long for the experiment while also having a good amount of time for the player to enjoy the experiences. A keyboard (i.e. ASDW keys) and a mouse (i.e. left click) were used as the player's input with an additional a camera (indirect input) in dynamic balancing system. Table 1 and Table 2 the dynamic balancing design for the game.

3.2. Rushing Escape: The 3D Game

Similar to the 2D game theme, Rushing Escape is a 3D game designed with outer space with Alien theme. However, the colour theme chosen in this game is quite bright to recreate the feeling of adventurous. In contrast with the 2D game, the camera is set to be a first-person view. The player is able to explore the world freely. The goal if the game is as simple as the 2D game: to find a purple diamond spawned in a random place located quite far away from the player. While the player is searching the diamond, the enemy will be spawned, move towards the player, and attack the player. If the player has killed 30 or more enemies, the boss will appear and fight the player. Similar to the 2D game, the level of the game is set to two levels, in order to not make it too long for the experiment while also having a good amount of time for the player to enjoy the experiences. The inputs used in this game is also identical with the 2D game. Table 1 and Table 2 the dynamic balancing design for the game.

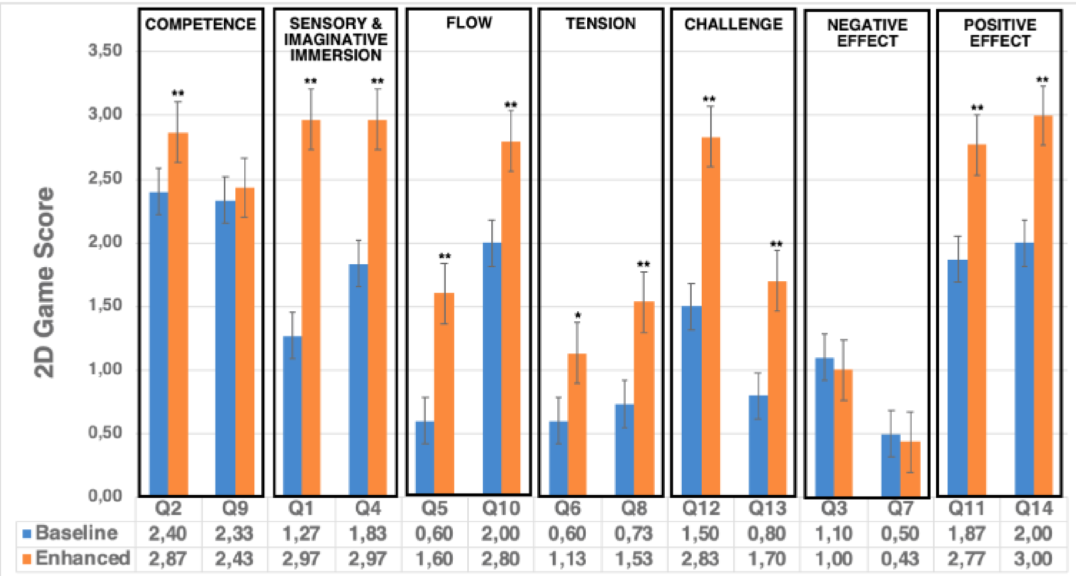
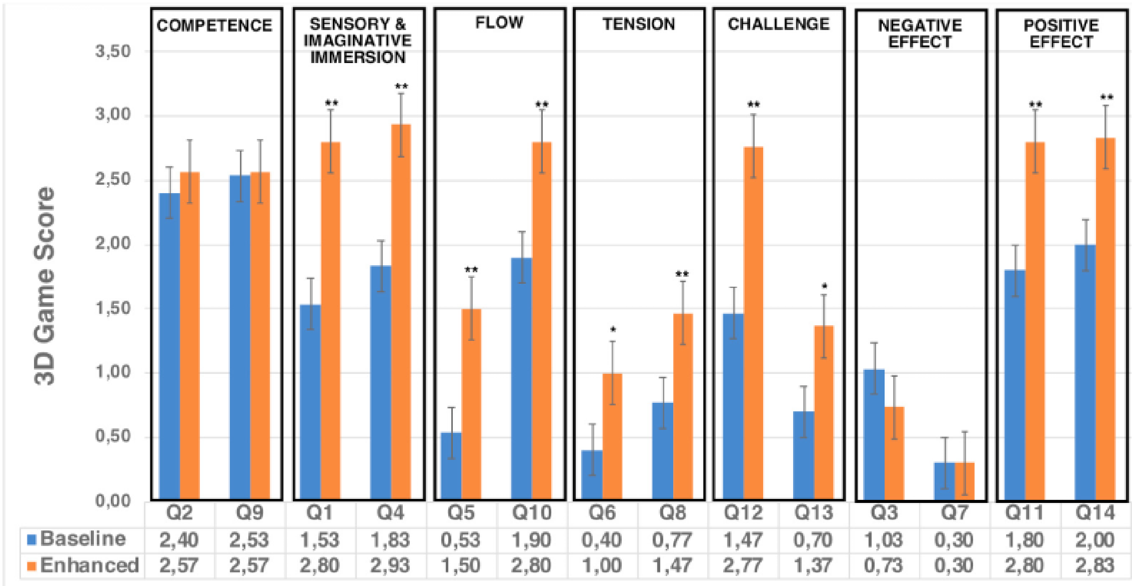


Fig. 4. 3D Game Play

4. Results

To evaluate the dynamic balancing system, two groups of 30 adults (between 18 - 40) respondents each group (total of 60 respondents, 68.33% Male) were recruited to play the games. The first group played with the 2D game, and the second group played with the 3D game. Both groups played with the game twice, the game with game balancing system activated (the enhanced game) and one without the balancing system (the baseline game). In order to prevent player's bias, the order was randomised and the players were not told anything about the dynamic balancing system in the game nor the FER system. Each respondent filled out five points Likert-scale questionnaire every time they finished playing a session of the game. The Game Experience Questionnaire (In-Game GEQ) [24] were used to evaluate the player's experiences when playing the game (please refer to the original paper for the questions). They are seven groups of variables defined by 14 questions in the Questionnaire. Fig. 4 shows the results of the 2D game and Fig. 5 illustrates the results of the 3D game categorised in seven-game experiences variables. A Shapiro-Wilk method applied to the data accepts the notion of the data most likely come from a normal distribution data ($p > 0.05$). Hence, a paired sample T-Test can be used to statistically compare the player's experiences between a game with dynamic balancing activated and the one with-out dynamic balancing system. In-Game GEQ consists of 7 variables of the experiences: Competence, Sensory & Imaginative Immersion, Flow, Tension, Challenge, Negative Effect, and Positive Effect. The detail of the questions (Q1-Q14) can be referred to the original paper [24].

In general, there is no statistically significant difference between groups (for both baseline and enhanced games, $p > 0.05$). In the 2D game group (see Fig. 4), there is a statistically significant difference (i.e. improvement) on five out of seven variables categories. They are Sensory & Imaginative Immersion (Q1 and Q4), Flow (Q5 and Q10), Tension (Q6 and Q8), Challenge (Q12 and Q13), and Positive Effect (Q11 and Q14). Double star mark (**) indicates that there is a statistically significant difference between baseline and enhanced games with $p < 0.01$, while the single mark (*) indicate that they are a statistically significant difference between baseline and enhanced games with $p < 0.05$. In the Competence variables category, only Q2 has a significant difference between baseline and enhanced games with $p < 0.01$. Finally, there is no statistically significant difference in the Negative Effect variables (Q3 and Q7) on the player's experiences ($p > 0.05$) between the baseline and enhanced games. Albeit they are no statistically significant difference in this category, the enhanced game resulted in a lower score (decrease) of the Negative Effect variables. While in the 3D game group (see Fig. 5), there is a statistically significant difference (i.e. improvement) on five out



	Q2	Q9	Q1	Q4	Q5	Q10	Q6	Q8	Q12	Q13	Q3	Q7	Q11	Q14
Baseline	2,40	2,53	1,53	1,83	0,53	1,90	0,40	0,77	1,47	0,70	1,03	0,30	1,80	2,00
Enhanced	2,57	2,57	2,80	2,93	1,50	2,80	1,00	1,47	2,77	1,37	0,73	0,30	2,80	2,83

Fig. 5. 3D Game Play

of seven variables categories. They are Sensory & Imaginative Immersion (Q1 and Q4), Flow (Q5 and Q10), Tension (Q6 and Q8), Challenge (Q12 and Q13), and Positive Effect (Q11 and Q14). Double star mark (**) indicates that there is a statistically significant difference between baseline and enhanced games with $p < 0.01$, while the single mark (*) indicate that they are a statistically significant difference between baseline and enhanced games with $p < 0.05$. Similar with the 2D Game, there is also a no statistically significant difference in the Negative Effect variables (Q3 and Q7) on the player's experiences ($p > 0.05$) between the baseline and enhanced 3D games. Albeit they are no statistically significant difference in this category, the enhanced game resulted in a lower score (decrease) of the Negative Effect variables. Finally, in the 3D game, there is no statistically significant difference in the Competence variables category (Q2 and Q3).

5. Discussion and Future Work

In this research, two games were developed with a Dynamic Balancing System by implementing FER system to capture the player's facial expression in real-time when they are playing the game. Captured facial expression is interpreted and used to dynamically adjust the game difficulty. Both games were evaluated in two groups, the first group played the 2D game: Alien Fighter and the second group played the 3D game: Rushing Escape. Each group played with the games twice, one with the dynamic balancing system installed in the game and one with-out the dynamic game balancing system. The results were statistically analysed using a paired sample T-Test method. The results show that in both game groups (i.e. 2D and 3D games) there is no statistically significant difference in the Negative Effect variables (Q3 and Q7) on the player's experiences ($p > 0.05$) between the baseline and enhanced games. Moreover, there are statistically significant differences in the five player's experiences categories in both game groups. In the 2D game, only 1 out of 2 variables (Q2) in the Competence category has the statistical difference between the baseline and enhanced games. While, in the 3D game, there is no statistically significant difference in this category. For the future work, other dynamic balancing variables (e.g. Enemy's Attack Point, Enemy's Health, etc.) can be explored. Finally, the research can be extended to a serious game setting where the speed of the learning depends on the individual set by the dynamic balancing system.

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